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E. J. BUTLER.

SCOTTISH SOCIETY FOR RESEARCH
IN PLANT-BREEDING

REPORT

BY THE

DIRECTOR OF RESEARCH

TO THE

ANNUAL GENERAL MEETING

13th July 1933



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SCOTTISH SOCIETY FOR RESEARCH IN PLANT-BREEDING.

R E P O R T

BY

DIRECTOR OF RESEARCH.

I. Research Programme.

The aim of the Society is to establish a thoroughly equipped Station, and to promote research on problems which might advance the technical knowledge of crop plant improvement, particularly with reference to those crop plants best adapted to Scottish conditions.

The crop plants on which breeding experiments are being carried out are chiefly Oats, Potatoes, Herbage (Perennial Ryegrass, Cocksfoot, Timothy and Plantain) and Swedes.

Reference was made in last year's report to the importance of the chromosomes in relation to plant-breeding. Cytologists are obtaining further evidence of the importance of the function of the chromosomes in heredity and in this connection it is of interest to quote Sir A. Daniel Hall, who, in a foreword to Dr Darlington's book, 'Chromosomes and Plant Breeding,' states in referring to the theory of nuclear structure: "sometimes the theory thus reached indicates to the plant-breeder the most probable means of arriving at a desired result; very often again it will warn him off unprofitable lines of attack and save wasted endeavour on what may seem on the face of it a promising venture."

Further, in consequence of the increased knowledge that has become available regarding chromosomes and the duplication of sets of chromosomes, various workers are now endeavouring to stimulate duplication of chromosome sets and so obtain plants with increased chromosome numbers. A plant which contains two or more sets of chromosomes is known as a polyploid; most varieties of oats cultivated in this country

are examples. Polyploids frequently, though not always, are more vigorous and are of greater size than their ancestors which have lower chromosome numbers. Through the duplication of chromosome sets many attractive possibilities are opened up for the plant breeder, and already certain definite results have been claimed. Certain of the wheat-rye and the swede-turnip hybrids referred to in Continental literature are examples of plants containing the chromosome sets of both parents. It is reasonable to expect that a collection of plants of this nature would greatly extend the range of plants for cross-fertilisation and for selection.

A scheme has recently been submitted for the purpose of enabling chromosome investigations being undertaken on an extensive scale at the Plant-Breeding Station. If this scheme is approved and put into operation the workers at the Station should then be in a position to apply the most recent knowledge regarding plant-breeding, and thereby be better able to promote the development of the Station and the production of improved varieties of plants.

A review of the work done and the results obtained at the Plant-Breeding Station during the past year follows.

A. CEREALS.

Oats.

The oat-breeding experiments were continued on an extensive scale, and all the ground available for oats was required for this crop plant. A large collection of hybrid material was grown for comparison and for selection of improved types, possessing, amongst other desirable characters, a good quality of upstanding straw and showing early maturity.

The study of the inheritance of grain colour in oat hybrids was continued with a view to obtaining further information bearing on the occurrence of grey-grained and black-grained plants in certain hybrid progenies. Several first-generation plants each of which bore well over 1000 grains were obtained last year, and these hybrids will be utilised mainly in connection with the investigation of the heredity of grain colour. An account of the work done at the Station in studying the inheritance of grain colour in oats was published in October last year in the 'Journal of Genetics,' Vol. XXVI., No. 2. The

inheritance of grain colour in twenty-five hybrids was described, and it was shown that certain parent varieties possessed one factor for black grain; that two varieties possessed one factor for black and one factor for grey; and that one variety possessed two factors for black and one factor for grey grain.

Several of the promising selections from the progeny of Castleton Potato $\times$ Yelder, which were referred to in the previous report, were found to contain a few segregating types. Further selections from these have therefore been made, and some of these possess a type of straw likely to be highly resistant to lodging. They also possess well-furnished panicles and have the appearance of being highly productive of grain. A few of the Orion $\times$ Sandy hybrids are being multiplied. They are markedly early-ripening types which may be suitable for certain late districts.

Twenty-one unnamed hybrid varieties, representing eleven different hybrids, and nine named varieties were grown in replicated plots for comparison. These plots were arranged in four blocks on the randomised plot method as followed in previous years. The figures obtained for yield of grain were subjected to statistical analysis, and this showed that several of the selected hybrids gave yields of grain not significantly lower than that of Victory. In 1932 Victory was one of the highest grain-yielding varieties in the trials, its yield of grain being at the rate of 81.4 bushels per acre. Two other varieties, one a hybrid from Beseler's Prolific $\times$ Orion and the other Marvellous, gave a slightly heavier yield of grain than Victory, but their yields could not be regarded as being significantly higher than that of Victory. Several of the hybrid types which gave a yield comparable with that of Victory ripen earlier than this variety, and they possess a better standing type of straw. One of these is No. Aa 644, Potato $\times$ Record, which gave a yield at the rate of 78.4 bushels per acre. The grain of this variety is of medium size and of good colour. The husk is not thick, the percentage of kernel being about 76.2. The grains of Record and Potato varieties show about 73.6 per cent and 77.3 per cent of kernel respectively.

A representative collection of named varieties of oats was, as usual, grown in small plots for observation.

Bell Oats.—About three acres of Bell Oats were grown under contract for the Society by the Department of Agriculture for Scotland at East Craigs, Corstorphine, in 1932. The crop was

satisfactory, and it was secured in excellent condition, the grain making a fine seed sample. About 80 cwt. were available for disposal as seed, and members of the Society were notified of the quantity for sale, the price being fixed at 10s. per cwt. All this seed was sold, and the demand was greater than the supply available.

In order to obtain further information regarding the Bell Oat, a request for a report was sent from the Plant-Breeding Station towards the end of 1932 to the various members of the Society who had purchased Bell Oats for seed earlier in the year. Reports from almost all the growers were received and most of these were favourable. It may be of interest to quote from two of these reports :—

- (1) From Captain Thomas Elliot, Thirlestane, Lauder—

“ I sowed these oats after turnips on a poorish field 880 feet above sea-level at the rate of 4 bushels per acre drilled in after being dressed with ‘ Ceresan.’ They were a very thick plant, grew a good crop, tall and all perfectly standing and when cut were dead ripe. They ripened at least a week earlier than the remainder of the field which was sown with Yelder. The yield of dressed grain was 20.8 cwt. per acre, and the natural weight of these oats was 45 lb. per bushel.”

- (2) From Mr George Henderson, Farm Manager, Ronachan Home Farm, Clachan, Kintyre :—

“ I must say we had an excellent crop, very fine straw and standing well when harvested, quite a good three weeks earlier than any other in the district. I have had several inquiries about the oats. I should think they will suit this countryside remarkably well.”

Registration Trials.—Two hybrid varieties of oats raised at the Station were included in the 1932 Registration Trials conducted by the Department of Agriculture for Scotland. One of these was No. Aa 635 which was selected from the progeny of the same cross as Elder. It has several characteristics in common with that variety, but its straw does not stand up very well and it does not ripen any earlier than Elder. On account of the quality of its straw and its rather late date of maturity it has been decided not to multiply this variety any further.

The other hybrid variety included in the trials was No. Aa 644 which, as already mentioned, was selected from the progeny of a cross between Potato and Record. This was the first year in which it had been included in the Registration Trials, but it has been included in some of the smaller observation plots at the Plant Registration Station in previous years. The report of the Registration Trials shows that Aa 644 gave the second highest yield of grain, the yield being at the rate of $29\frac{1}{2}$ cwt. per acre. Record, which gave the highest yield of grain in the trials, produced $30\frac{1}{4}$ cwt. of grain per acre. In order of ripening No. Aa 644 was placed first. It was cut on 19th August, the other varieties which were placed second in order of maturity being cut on 23rd August.

In view of inquiries having been made as to the feeding value of the grain of Elder and Bell oats, arrangements were made to make a chemical analysis of these. Dr Alexander Lauder, Chemistry Department, Edinburgh and East of Scotland College of Agriculture, kindly agreed to make the analysis of these varieties and also of the grain of the varieties Potato and Sandy for comparison. The results of Dr Lauder's analysis are shown in Table I.

TABLE I.

ANALYSIS OF SAMPLES OF OATS RECEIVED FROM PLANT-BREEDING STATION—27TH FEBRUARY 1933.

VARIETY Reference No.	ELDER Aa 612.	BELL Aa 605.	POTATO Aa 10.	SANDY Aa 2.
Crude Protein (Albuminoids)	9.12	10.91	11.54	11.19
Oil (Ether Extract) . . .	4.36	4.37	3.46	4.29
Crude Fibre	8.72	8.23	6.83	9.62
Soluble Carbohydrates . .	60.26	59.92	62.32	57.48
Mineral Matter	3.14	2.51	2.50	3.02
Moisture	14.40	14.06	13.35	14.40
	100.00	100.00	100.00	100.00
Weight of 1000 grains in grams	35.83	33.81	31.52	27.61

The above analyses show differences in the amounts of the various constituents. As regards the more important of these, the grain of Elder and Bell varieties is considerably higher in oil content than that of Potato; in soluble carbohydrates Potato is highest and Sandy lowest. The higher soluble carbohydrate content of Potato is counterbalanced by its low oil content. Elder and Bell both show a lower protein content than Potato or Sandy. On the whole, however, there would seem to be little difference in the feeding value of the grain of any of the above four varieties.

Table II. shows the percentages of kernel found in samples each consisting of 1000 grains of the four varieties, Elder, Bell, Potato and Sandy.

TABLE II.

VARIETY Reference No.	ELDER Aa 612.	BELL Aa 605.	POTATO Aa 10.	SANDY Aa 2.
Percentage kernel . .	74.9	77.9	77.3	77.8

Barley.

In addition to the usual collection of barleys which were grown, various hybrid selections received from Mr Thomas Anderson, Director of the Seed-Testing Station, Corstorphine, were also grown for observation. In consultation with Mr Anderson, the number of selections was reduced at the end of the season, and several were retained for further trial in 1933.

A single plant selection of barley, Ref. No. Ac 78, received several years ago from Mr G. Bertram Shields, Rosebery Farm, Gorebridge, has been increased in quantity and compared with ordinary strains of Plumage Archer from which variety it was selected. In its botanical characters this selection is similar to Plumage Archer, but the results of two years' trials have indicated that its straw is rather stronger and also that it ripens slightly earlier than the commercial selection of Plumage Archer.

Wheat.

A collection of hybrid wheats was grown for observation by Mr J. M. S. Lang, who also carried out the details of the work with barley.

In addition to the hybrid wheats, a few selections taken from a field crop of Squarehead's Master were grown for comparison and selection. Several of these strains appear to be worth further trial, and they are being grown on a larger scale in 1933 for further comparison.

B. POTATOES.

Assistant in Charge—WILLIAM BLACK, B.Sc., Ph.D. (Ainville Sub-Station).

The aim of the experiments is to produce new varieties of economic utility and to obtain information which will lead to the principles which govern the transmission of the more important characters of the potato being better understood.

First-year Seedlings.—Over 2000 seedlings were raised during 1932, of which two-thirds were obtained by hybridisation and the remainder by self-fertilisation. Among the hybrid seedlings there were families derived from :—

Abundance	× 135(10) ;	Abundance	× Herald ;
British Queen	× 135(10) ;	British Queen	× Herald ;
Up-to-Date	× 135(10) ;	Kerr's Pink	× Herald ;

America	× 121(2) ;
May Queen	× 121(2).

These progenies contained a large proportion of early-maturing seedlings and very few obviously undesirable types were observed. With the exception of those derived from Kerr's Pink × Herald the tubers as a general rule were white-skinned and of good shape. Of the seedling parents, No. 135(10) is a promising second-early variety which will be grown in the Third-year Registration Trials in 1933, and No. 121(2) is a good quality maincrop which gave satisfactory results in the First-year Registration Trials in 1932.

The selfed seedlings were grown chiefly to study the effect of repeated self-fertilisation and to obtain relatively true-breeding varieties. Several families have reached the F_6 generation, and others the F_5 . The majority of these lines appear to be breeding true in respect of particular characters, but in all cases a certain amount of segregation is still taking place. The lines in general are still fairly vigorous, but it is probable that the more vigorous are also the more heterozygous.

Second-year Seedlings.—About 500 seedlings were grown in small plots and examined and compared with standard commercial varieties. A good proportion of them gave satisfactory results, among which the following parental combinations were the most outstanding :—

America	×	135(10)	(Abundance × Majestic)
Abundance	×	120(64)	(A Great Scot seedling)
British Queen	×	120(4)	(do. do.)
British Queen	×	70(13)	(A Bishop seedling)
Kerr's Pink	×	70(13)	
British Queen	×	Majestic	
May Queen	×	Flourball	

Third-year Seedlings.—These seedlings numbered over 150 and were grown in Trial and Multiplication Plots, ranging from 3 to 114 plants. Standard commercial varieties were used as controls. Outstanding seedlings, in addition to those already included in the Registration Trials, were fairly numerous and the parents of some of the best ones are :—

Abundance	×	Flourball ;	Epicure	×	135(10) ;
Ally	×	Flourball ;	Epicure	×	Flourball ;
Kerr's Pink	×	966b(4) ;	Up-to-Date	×	Majestic.

Trials of about 240 selections raised at Ainville were carried out at the Plant-Breeding Station, Corstorphine. They were compared from a commercial point of view, and their probable degree of utility was ascertained by comparison with standard named varieties.

Multiplication and Trial Plots of several of the more promising seedlings were also grown at the Virus Research Station, Huntly.

As a result of the various trials, eight seedlings have been forwarded for inclusion in the Registration Trials carried out by the Department of Agriculture for Scotland in 1933. (See Table III.)

TABLE III.

NOTES WITH REFERENCE TO THE EIGHT SEEDLINGS WHICH ARE BEING INCLUDED IN THE REGISTRATION TRIALS OF THE DEPARTMENT OF AGRICULTURE FOR SCOTLAND IN 1933.

Reference Number.	Parentage.	Maturity.	Tuber.		Cooking Quality.
			Shape.	Colour.	
138(2) . .	Abundance × 121(6)	Maincrop	Oval	White	Very good
139a(34) .	Bishop × Flourball	Early-Maincrop	Oval	White	„
139a(38) .	Bishop × Flourball	Early-Maincrop	Oval	White	„
151(39) . .	Kerr's Pink × 966b(4)	2nd-Early	Oval	White	„
151(80) . .	Kerr's Pink × 966b(4)	1st-Early	Round	Pink	Good
151(116) .	Kerr's Pink × 966b(4)	Maincrop	Oval-Kidney	White	Very good
967c(38) .	Bishop × 800(2)	Maincrop	Oval	White	Good
D9(9) . .	Up-to-Date × Majestic	Maincrop	Oval	White	„

General Breeding Work.—Season 1932 proved to be very suitable for the production of potato berries especially among early-maturing varieties, both hybrid and selfed berries being plentiful. The first-year seedlings, however, presented the usual difficulty of obtaining plants sufficiently strong and well-developed for seed production. Consequently, in the inbreeding experiments it is not always possible to advance one generation every year.

Genetical and cytological investigations were carried out on various species of tuber-bearing *Solanums* and on cultivated varieties, with a view to ascertaining the nature of sterility and the mode of inheritance of various characters in these plants. Male sterility and interspecific incompatibility are commonly found, and the latter is not confined to plants having different chromosome numbers. Several wild *Solanums* breed true to type, and it is probable that through them information may be obtained which will materially assist in the elucidation of genetical problems in the cultivated potato.

Field Trials.—One seedling (No. 135(10)) was grown in the Second-Year Registration Trials of the Department of Agriculture for Scotland in 1932, and has been recommended for inclusion in the Third-Year Trials in 1933. It has finely-shaped tubers and it is a very attractive type of seedling.

Four seedlings were grown in the First-Year Registration Trials in 1932, and three of them have been recommended for inclusion in the Second-Year Trials in 1933. A few notes regarding these seedlings are given in Table IV.

Samples of seedlings were grown in the Single-Tuber Trials at Philpstoun; in the Miscellaneous Trials at East Craigs, Corstorphine; and in the Laboratory Wart Disease Tests carried out by the Department of Agriculture for Scotland.

Two seedlings were included in the Wart Disease Immunity Trials carried out by the Ministry of Agriculture and Fisheries at Ormskirk in 1932. The results of the trial were encouraging, and the seedlings have been recommended for inclusion in the Second-Year Test in 1933. Several seedlings were also included in the Preliminary Trials.

A further group of seedlings will be included in the trials in 1933.

TABLE IV.

NOTES WITH REFERENCE TO FOUR SEEDLINGS REFERRED
TO ON PAGE 10.

Reference Number.	Parentage.	Maturity.	Tuber.		Cooking Quality.
			Shape.	Colour.	
135(10) . .	Abundance × Majestic	2nd-Early	Oval	White	Very good
136(50) . .	Abundance × Shamrock	Maincrop	Roun- dish Oval	White	„
138(69) . .	Abundance × 121(6)	Maincrop	Oval	White	„
121(2) . .	Witchhill × 25(2)	Maincrop	Oval	White	„

C. HERBAGE PLANTS.

Assistant in Charge—J. W. GREGOR, Ph.D., F.L.S.

The investigations in progress at this Station and elsewhere suggest that any agricultural grass species can be subdivided into numerous races differing in both external appearance and physiological properties, and that the proportions of these minor units can be allocated a definite place in agricultural practice. For example, even two pasture strains requiring similar climatic conditions may have distinct economic values depending on whether they are cultivated on soils of high or low fertility or whether they are grazed by dairy stock or sheep. Perhaps the most important problem before the breeder of herbage plants at the present time is to produce strains adapted to particular conditions, especially the production of strains suited to low-fertility soils so as to

improve the value of the pastures on those soils. The conception of what constitutes a desirable grass strain for pasture purposes is subject to a certain amount of modification from time to time in consequence of the success or failure of particular strains when tested by individual farmers practising in dissimilar agricultural districts. Recent experiments have indicated that, just as in the evaluation of the degree of utility of strains, individual types must be compared on the basis of their suitability to some particular set of environmental conditions. Plant breeders should therefore endeavour to produce particular types for specific purposes.

The critical study of plant races and their ecological distribution forms an important part of the herbage plant research programme of this Station. The agricultural utilisation of races specially adapted to particular environmental conditions is the aim of these investigations, and as the work progresses the multiplicity of local varieties within a single species becomes more and more evident. In view of the possibility of an increased number of strains of grasses being placed on the market in the near future, carefully conducted trials of new grass strains must be made before they are put into commerce, or the choice by the farmer of the most suitable strains for any specific purposes will become increasingly difficult.

The organised testing of grass strains is perhaps one of the most important herbage problems of the future, but the collection of scientific information relating to the subject deserves immediate consideration.

Much time during the past year has therefore been devoted to the study of regional races, particularly of sea plantain and various problems regarding the differentiation of strains, and the maintenance of cross-fertilising populations at a desired equilibrium have been investigated. The work has entailed the critical examination of many geographical and ecological races of several species of *Plantago*. Sometimes the regional differences are obvious, but more frequently they are of such a nature as to preclude the usage of the recognised descriptive botanical terms. The characteristics of many races differ qualitatively rather than quantitatively, and this fact necessitates an examination of possible methods of determining and recording their racial differences. An attempt is also being made to correlate certain characteristics exhibited by regional

racess with the prevailing environmental conditions of their respective habitats.

The above-mentioned investigations have involved a large number of character measurements: over 60,000 measurements, and the attendant calculations thereon, being made annually. The help of the Junior Assistant, Mr J. M. S. Lang, has greatly facilitated the progress of this statistical examination. Although the work has now been in progress for several years it is as yet too early to formulate any definite conclusions.

In addition to the study of these general problems intensive breeding work with timothy, cocksfoot, and perennial ryegrass has been undertaken; the work with timothy, however, being on the most extensive scale of the three. Four new strains of grasses have now reached the field-trial stage. In 1932 seed stocks of these strains—two of timothy (the diploid type), one of perennial ryegrass, and one of cocksfoot—were multiplied at Corstorphine. The above strains, with the exception of one of timothy, were also multiplied under contract with the Society at the National Institute of Agricultural Botany, Cambridge, where satisfactory yields of seed were obtained.

The quantities of seed of the various strains available for sowing in trial-plots in 1933 were as follows:—

Timothy (diploid type), Ref. No. Cb 190	.	.	150 lb.
Timothy (diploid type), Ref. No. Cb 191	.	.	18 „
Perennial Ryegrass, Ref. No. Ca 430	.	.	189 „
Cocksfoot, Ref. No. Cc 180	.	.	271 „

D. ROOT CROPS.

(*Swedes and Turnips.*)

Assistant in Charge—V. E. M'M. DAVEY, B.Sc., Ph.D.

The chief results of the experiments with swedes are summarised in the following part of this report.

Pedigree Breeding.—About 170 strains of swede, and a few rape and turnip samples, were sown in small plots with certain commercial varieties as controls; while larger plots of most of the swede strains were sown in various groupings for the purpose of comparative trials. Observations were made periodi-

cally on all the plots during the season, and in autumn representative selections were made for propagation. The 'Roots' Sub-Committee inspected the trials at the end of October, and decided that two strains Ds 21 and Ds 22 should be further tested on a field scale and that a strain, which has shown a fairly high degree of resistance to finger-and-toe disease in small scale trials, should be multiplied for field tests. Concurrently about 250 samples of *Brassica* seed were harvested under controlled breeding conditions.

Analysis of Hereditary Characters.—Further investigations were made on the manner of inheritance of various characters, such as yield, dry-matter percentage, shape of bulb, colour of flesh and skin, type of foliage, disposition to bolt, malformation of bulb and resistance to finger-and-toe disease.

(1) *Leaf Shape.*—Many observations are annually made on the small and somewhat vague variations in size and pattern of swede leaves, because of their effect on improving or marring the appearance of a strain, and also because of their probable differences in efficiency as workshops for the elaboration of the foodstuffs to be stored in the bulb. It is, however, the heredity of a major variation which will be discussed here. It was investigated by Dr Hallqvist in 1916, and the present observations in general confirm his findings. Certain swede strains, as for instance a variety used in kitchen gardens in this country, have a simple leaf, shaped rather like that of a primrose with the blade in one piece, irregularly indented along the margin, but not deeply cut into lobes or divided into leaflets (fig. 1). When a swede with the normal much-lobed and divided leaf is crossed with one having 'primrose' leaves, the first hybrid generation has fully-lobed and almost 'normal' leaves, though it was here noted that the end lobe was larger or considerably longer than usual. In the second hybrid generation three types may be distinguished, apart from numerous minor variations in pattern; firstly the *normal* lobed and divided type with end-lobes of various lengths and sizes, secondly a type with a large blade, but numerous pairs of very small leaflets or deeply-cut lobes on the basal part or stalk, and thirdly the 'primrose' type with no deep lobing, so that the blade extends down to the leaf base. The second type (fig. 2) is unlike either parent, while the third is identical with the 'primrose' parent. The proportions in which these types occurred in 1932 approximated the ratio 12 normal: 3 semi-

SWEDE LEAVES ILLUSTRATING VARIATIONS
IN SHAPE.

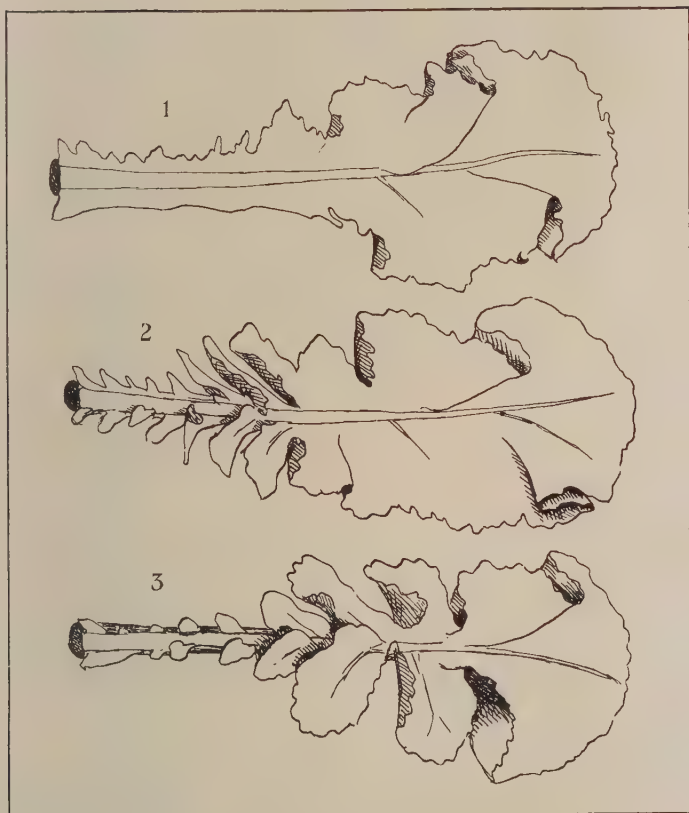


FIG. 1. Leaf Shape in Swedes :—

- (1) "Primrose."
- (2) Semi-lobed.
- (3) Normal.



FIG. 2.

Swede Strain DS 21. Light Bronze Top.



FIG. 3.

Swede Strain DS 22. Purple Top.

lobed : 1 primrose. The probable explanation of this segregation is the action of two different factors. When both are absent the leaf is 'primrose,' the presence of one factor gives the semi-lobed condition, while if the other factor, or both, is present the leaf is of normal type. More observations will be necessary to confirm this ratio. From the practical standpoint the experiments have shown that crossing with the 'primrose' leaf form is not likely to bring to light any new shaw type of economic value, since the semi-lobed and 'primrose' leaf forms seem to be unsuitable for field conditions, being brittle and exposing the 'crown' of the plant. It may be mentioned that the 'primrose' leaf shape has been recognised by some systematic botanists as a distinct subdivision of the swede species. In turnip a similar 'primrose' shaped leaf occurs, *e.g.*, in Early Milan variety.

(2) '*Bulbless Bolters*.'—In 1930 it had been noted that great variation in bolting tendencies occurred in a variety of swede-like rape, which was growing under conditions similar to swede cultivation. Plants of extreme types were selected and seeded, and their progenies were sown out in May 1932 in drills like swedes. In September the progeny of a fully-bolted rape plant consisted of 24 plants in flower out of 32, while the progeny of a non-bolter contained only one bolting plant out of 18, the remainder showing little or no tendency in this direction. The progeny of the bolted plant, in respect of bolting tendencies and general appearance, resembled one of the lines of 'bulbless bolter' which had hitherto been unmatched with rape. Assuming that the 'bulbless bolters' found in swede crops are generally pure swede-like rape plants, as the evidence which is being accumulated seems to indicate, the question arose as to why the progenies of the specimens sent to this Station were frequently more inclined to bolt than any of the samples of rape used as controls. It seems possible that these specimens were the most conspicuous in the field at the time of choosing them, and that other unbolted, bulbless plants may have been overlooked. Thus an unconscious selection of bolting tendencies was taking place. In one commercial green-top swede crop grown at this Station, numerous unbolted bulbless plants were found, whose progenies strongly resembled varieties of rape. Among the swedes these plants might have been noted by their darker foliage, but were otherwise inconspicuous till lifted. The

term 'bulbless bolter' is therefore somewhat misleading, while the other name, 'Bastard Bolter,' is even less apt for the majority of specimens observed, though it does fit the infrequent but serious cases where rape has been allowed to flower in or near a propagating swede crop so that hybridisation with swede plants has taken place, giving very undesirable hybrid offspring.

Feeding Quality Investigations.—Dry-matter percentage and weight or yield were again used for comparisons, while in some trials soluble solids content and sugar tests were also made. Three yield trials were carried out; in one which the three mass-multiplied strains were tested against various control varieties; in the second some L_3 lines were compared as they had been in earlier generations since they were selected as single bulbs from a commercial crop; while in the third yield trial a number of third hybrid generation strains were compared for dry-matter and yield, forming a progeny trial by which the hereditary qualities of their parents might be checked.

Some smaller plot tests were made, mainly with pedigree lines and hybrids between them to observe the effects of inbreeding and outbreeding. Several populations were subjected to single bulb analysis of dry-matter percentage and weight for the purpose of selecting desirable combinations of characters. Second hybrid generations of crosses between pedigree swede lines were employed in this connection.

E. VIRUS DISEASE RESEARCH.

(Under Empire Marketing Board Grant.)

E. C. BARTON-WRIGHT, M.Sc., F.R.S.E., *Chief Assistant, Craigs House.*

GEORGE COCKERHAM, B.Sc., *Assistant, Huntly Sub-Station.*

ALAN M. M'BAIN, B.Sc., *Assistant, Ainville Sub-Station.*

In 1932 physiological work on the virus diseases of the potato was continued at the Corstorphine Station. The carbohydrate metabolism of healthy and crinkle-infected potatoes was examined. Contrary to the results obtained for leaf-roll in 1931, it was found that this disease apparently does not interfere to any marked extent with the formation of sugars

in the leaf. A certain amount of evidence was obtained showing that transport of sugars out of the leaf was slightly interrupted. Examination of the data as a whole, however, showed that decrease in the number of ware-size tubers from plants affected with this disease cannot be correlated with carbohydrate formation, and the cause of the loss must be looked for elsewhere. The results of this investigation will shortly be available.

The crinkle-like disease discovered by Salaman to be carried by King Edward plants, and called by him 'para-crinkle,' was also investigated. Every plant of King Edward (sixty in all) examined for the disease was found to carry it in a latent condition.

An examination of the protein metabolism of leaf-roll plants was made at this Station as well as at Ainville Sub-Station. This work was a continuation of a preliminary investigation of the subject which had been made in 1931. It was found that the formation of proteins and other nitrogenous compounds proceeds along the same lines in healthy and diseased plants, and beyond a small slowing up of the rate of formation in the leaf-roll plants, there is no fundamental difference to be found in the two series, as has been considered heretofore.

A commencement was made in 1932 of genetical work on healthy and diseased plants. A number of crosses between healthy and diseased plants were secured, and the progenies are being grown this season at the Huntly Sub-Station. A further extensive programme of genetical work has been laid down for 1933 in an endeavour to ascertain (1) whether resistance to virus diseases in the potato can be discerned as a genetical factor, and (2) whether any of these diseases are carried in the true seed, and (3) which, of a number of varieties, are resistant or partially resistant to different virus diseases.

Huntly Sub-Station.—It has been noted previously (Annual Report for the year ended 31st March 1932) that virus diseases have a profound effect on the breeding qualities of potatoes. In general, seed from parents infected with virus diseases was observed to be less viable and to produce more degenerate seedlings than seed from correspondingly healthy parents. Although conditions in 1931 were not favourable for breeding, a small quantity of seed was obtained from plants affected with leaf-roll, crinkle, or simple mosaic, and this seed has

yielded data on more quantitative lines than formerly. The data support the conclusions drawn from the preliminary work, and extend them to show that leaf-roll and crinkle have the greatest effect in producing degeneracy in the seedling progeny. Seedlings derived from plants affected with simple mosaic appear to lack vigour and exhibit 'waviness' of the leaves, but are nevertheless comparable with seedlings derived from healthy parents with respect to the occurrence of degenerate plants.

In continuation of this work further seed was obtained from healthy and diseased parents and also from reciprocal hybridisations between healthy and diseased plants, with the object of determining whether degeneracy is due to transmission of any principle through the male or female parent or to physiological changes affecting the pollen or ovule. Where possible, tubers were obtained from degenerate plants for the purpose of making detailed anatomical studies in 1933.

During the past three seasons observations have been made on the reaction of several self-fertile varieties to viruses of the simple mosaic, crinkle and leaf-roll groups. The visible expression of symptoms, vigour, and yield were taken as indications of resistance or susceptibility, and seed has been obtained from varieties adjudged to be the most resistant and the most susceptible in order to ascertain whether such resistance is inherited on Mendelian lines.

An experiment designed to obtain data on the nature of susceptibility in the variety Golden Wonder, has yielded results which indicate that this variety is actually resistant to certain virus diseases and may act as a symptomless carrier. As a corollary to this work the possibility that injury to the tubers, sprouts, or stem caused the visible expression of virus infection was examined. In no case was proof obtained that injury alone produced symptoms on a previously symptomless plant. It appears, therefore, that any 'spontaneous' production of symptoms in the field is due to infection from an extraneous source, the infection probably taking place through an injured part.

An investigation into the carbohydrate metabolism of normal and mosaic-infected potato plants has been in progress throughout the year. Material has been obtained from three varieties over periods of twenty-four hours at three stages of growth, viz., actively growing, fully grown and mature stages. The

results obtained from this material were such that it was considered necessary to obtain further data from the very early stages of growth. The investigation is still in progress, but the results should be available shortly.

Seedlings of possible economic types have been raised for the purpose of comparison with similar seedlings grown in different environments in the south of Scotland.

A collection of mosaic diseases from various sources has been made, and an attempt made to classify them according to the reactions produced upon transmission to certain standard varieties and other solanaceous hosts.

II. Publications and Lectures by Staff, for the Year ended 31st March 1933.

PUBLICATIONS (P) AND LECTURES (L).

Director of Research :—

“Oat Breeding: Notes on two New Varieties of Oats recently registered by the Department of Agriculture for Scotland.” *Scottish Journal of Agriculture*, Vol. XV., No. 3, July 1932. (P)

“Notes on the inheritance of Grain Colour in Certain Oat Hybrids.” *Journal of Genetics*, Vol. XXVI., No. 2, October 1932. (P)

“The Work of a Plant-Breeding Station.” Yarrow and Ettrick Pastoral Society, 15th December 1932. (L)

“Oat Varieties and the Oat Crop in General.” Condorrat and District Agricultural Discussion Society, 16th February 1933. (L)

J. W. Gregor, Ph.D., F.L.S., Chief Assistant :—

“Experimental Delimitation of Species.” A reply. *Journal of Botany*, May 1932. (P)

“The Value of Specific Criteria.” Inter-University Biological Conference, Edinburgh, 28th January 1933. (L)

V. E. M'M. Davey, B.Sc., Ph.D., Assistant :—

“The Method of sampling Swede Bulbs by Cores.”
Journal of Agricultural Science, Vol. XXII., Part IV.,
October 1932. (P)

E. C. Barton-Wright, M.Sc., F.R.S.E., Chief Assistant, and
Alan M. M'Bain, B.Sc., Assistant (Virus Disease
Research Scheme) :—

“Studies in the physiology of Virus Diseases of the
Potato: A comparison of the carbohydrate meta-
bolism of normal with that of leaf-roll potatoes.”
Transactions of the Royal Society of Edinburgh,
Vol. LVII., Part 2, No. 11, 1931-32. (P)

George Cockerham, B.Sc., Assistant, Huntly Sub-Station,
(Virus Disease Research Scheme) :—

“Variations in the Total Nitrogen Content of Normal
and Leaf-roll Potatoes.” Proceedings of the Leeds
Philosophical Society, Vol. II., pp. 375-382, January
1933. (P)

“Scottish Work on Virus Diseases of Potatoes.” Biology
Colloquium of the University of Leeds, 27th February
1933. (L)

VISITS.

Director of Research :—

West of Scotland Agricultural College, Experiment
Station, Auchincruive, Ayr.

J. W. Gregor, Ph.D., F.L.S., Chief Assistant :—

Macdonald Agricultural College, Ste. Anne de Bellevue,
Quebec, Canada.

Central Experimental Farm, Ottawa, Canada.

Canadian National Exhibition, Toronto, Canada.

Ontario Agricultural College, Guelph, Ontario, Canada.

Gray Herbarium, Cambridge, Mass., U.S.A.

Yale University, New Haven, Conn., U.S.A.

Connecticut Agricultural Experimental Station, U.S.A.

The visits referred to above were made possible by a financial grant from the Empire Marketing Board Fund. Mr J. M. S. Lang unofficially accompanied Dr J. W. Gregor to Canada and U.S.A.

III. Demonstrations.

Several agricultural parties and a number of research workers visited the Station at Corstorphine and the Sub-Station at Huntly, Aberdeenshire, at different periods throughout the year. The visitors were conducted round the experimental plots, and various aspects of the work at the Stations were described by members of the staff.

IV. Acknowledgments.

Grateful acknowledgment is made to the undernoted departments, institutes, firms and individuals for gifts of samples or other material for experiment :—

- Department of Agriculture for Scotland, Seed-Testing Station, Corstorphine, Edinburgh, per Thomas Anderson, Esq., Director.
- Bell, David, Esq., J.P., 15 Coburg Street, Leith.
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- Clausen, Dr Jens, Carnegie Institute of Washington, Stanford University, California, U.S.A.
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 York Buildings, Queen Street, Edinburgh.

Royal Botanic Gardens, Kew, Surrey.

Salaman, Dr R. N., Plant-Breeding Institute, Cambridge.

Smith, Chas., & Son, St John's Road, Corstorphine,
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Stanton, T. R., Esq., United States Department of
 Agriculture, Washington, U.S.A.

Turesson, Dr Göte, The University, Lund, Sweden.

Weatherby, C. A., Esq., Gray Herbarium, Harvard
 University, Cambridge, Mass., U.S.A.

Young, T. H., Esq. (A. Riddell & Co.), 5 Grassmarket,
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Thanks are also due to the Director of the Seed-Testing and Plant Registration Station, Corstorphine, Edinburgh, for carrying out laboratory tests on potato seedlings for susceptibility to wart disease; to members of the staffs of the three Scottish Agricultural Colleges who arranged and supervised the trials of certain of the Society's new varieties of oats; and to Dr Alexander Lauder, Edinburgh and East of Scotland College of Agriculture, Edinburgh, for making chemical analyses of samples of oats.

WILLIAM ROBB,
Director of Research.

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